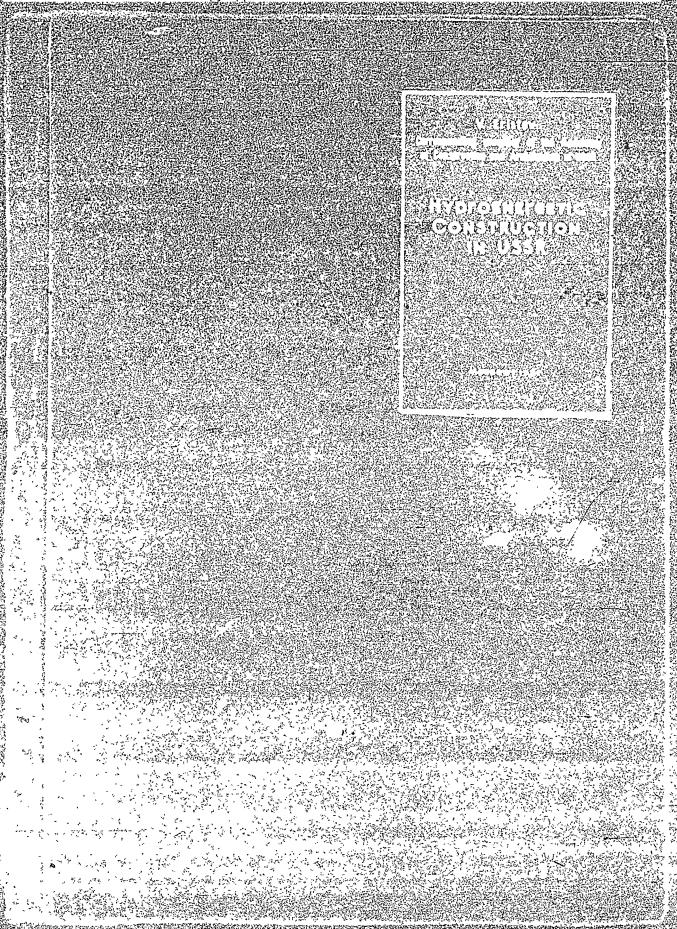
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HYDRO-POWER CONSTRUCTION IN THE USSR

Hydro-power resources of the USSR are very great and comprise 15% of the world resources.

Potential hydro-power resources of the USSR are estimated approximately at 3000 billions kwn which correspond to the capacity of 340 million kw.

It is possible to utilize technically the resources of 1700 billion kwh or 58% of the potential.

The Soviet Union occupies the second place in the world in hydro-power wealth after the People's Republic of China.

Before the Great October Revolution there were literally no hydro-power stations if some small hydro-power stations of aggregate capacity of 16000 kw not to be taken into consideration.

After the October Revolution the development of the water resources was especially rapid in accordance with the State Plan of Electrification of Russia (GOELRO-Plan) adopted by the Eighth All-Russian Congress of Soviets under V.I.Lenin's initiative in 1920 and followed after that by the Five-Year Plans of the USSR national economy development.

The Soviet Covernment always pays the greatest attention

to the electrification of our country regarding it as a material and technical basis of socialism.

We to now about 120 medium and large power stations have been built (act taking into account rural power plants) with more than 9 mill. kw aggregate capacity, 25 hydro-power stations of about 14 mill. kw aggregate capacity being under construction

It should be noted that in the Second World War a number of hydro-power stations with 1 mill. kw aggregate capacity were destroyed by the Hitlerites. All these stations had to be restored.

The hydro-power plant output amounted to 29 bill. kwh in 1956 and hydro-power specific weight in the power balance of the USSR was 15.1% in 1957.

In spite of considerable development of water resources in absolute value in the USSR, in percentage to total resources is still not very great and now comprises in the European part of the USSR only 9.5% and on the whole USSR - 1.7%.

Therefore the Sixth Five-Year Plan (1956-1960) of national economy development of the USSR provides for further and wider development of hydro-power stations and the power capacity increase 2.7 fold in comparison with 1955 to achieve the hydro-power output up to 59 billion kwh.

The hydro-power specific weight in power balance will be 18.5% in 1960.

The characteristic features of hydro-power construction development of the USSR are as follows:

- 1. Integrated water resources development.
- 2. Planned and full river utilization by means of construct-

ion of hydro-power station cascades.

- 3. Hydro-power plant construction in most different nature, areas of the country and of various types.
- . 4. Constant power increase of hydro-power plants under construction and their separate units.
- 5. Consolidating hydro-power plants into power-systems with steam-power plants and large-scale automatization and hydro-power station telecontrol development.
- 6. High rate mechanization in construction and usage of high ly productive machines that gives the possibility to fulfil great volume of work in relatively short period of time.
 - 7. All mentioned items are considered below.

Integrated Water Resources Development is characterized as follows: while constructing or designing this or that hydroproject not only the problems of hydroenergetics, but also the problems of water transport, irrigation, fish economy, water supply, railway and automobile transport, the problems of timber economy, industrial development of a hydro project region and so on should be settled simultaneously.

All-sided surby of all these factors often defines the site choice and main hydro-power station parameters.

For example the construction of hydro-power plants on the Volga, Dnieper, Svir, Ob and other rivers improved radically the conditions of navigation on them. The Volga earlier was a river where navigation met considerable difficulties because of shallow water in periods of low water.

Now the Volga is being converted in the first rate deep trunk water way with guaranteed depths not less than 3.0 m On the Dnieper which was not navigable in its middle stream due to rapids a deep trunk water way is being created from Kiev down to the Black Sea as well. Along with it draught region problems of Trans Volga areas are being tackled, pasture watering of Caspian Low land, the development of domestic water-

allowing big river vessels to sail with a great lifting capacity

supply and industrial Volga regions, irrigation of draught regions of the low Unieper left bank, the Northern Crimea and

Kerch industrial region.

Reservoir of the Kakhovka hydro-power plant will provide the irrigation of the Southern part of the Ukraine ateppe areas and bringing water through the canal to the Krivoi Rog are basis using the canal in transport purposes as well (transporting ore and timber). The Novosibirsk and Kamensk hydro-power plant reservoirs on the Ob will provide the irrigation of Kulinda arid steppe in Vestern Siberia.

The Ivankov Mydro-project construction on the Volga and the Moscow canal settled the question of navigation between the Moskwa and Volga rivers and the problem of Moscow water supply and increase of average discharge of the Moskwa River.

The construction of the Volga-Don navigable Lenin Canal and Tsimlyanskaya hydro-power station on the Don assured the connection of the Volga with the Sea of Azov and Arrigation of large areas in Stalingrad District and Rostov Region.

The fish-plants for the intensification of fish economy are formed within all the reservoirs.

The Wingechaur high-dam construction on the Kura River forming a vast reservoir made it possible to irrigate Kura-Araz low; land and protection the Kura low stream from harmful flood stream causing formerly innumerable disasters.

Derivation canals of many Middle Asia hydro-power plants and the Caucasus are at the same time trunk canals of irrigation systems such as the Perepadnaya hydro-power plant in Tadjikistan Samgori system in Georgia and others.

All the hydro-power plant dams provide the automobile transport movement and most hydro-projects on the big rivers have railway lines along the dams so that it is not necessary to built special bridges.

The settlements for the workers and auxiliary stationary enterprises for instance repair mechanical works, pre-fabricated reinforced concrete plants, wood treatment works are used as a basis for industrial region development after the end of hydre-project construction.

Planned and Complete Utilization of Rivers by rears of Construction of Power Plant Cascades Rises the

Efficiency of Hydro-Resources Development

While solving this problem separate, profitable river sectors are not chosed, but preliminary more rational program to take into considration all the favourable aspects of the river and its tributaries and only after this it becomes possible to build the power projects of vital necessity.

The erection of hydro-power cascades on the Neva and Svir Rivers has been completed in the Soviet Union at present. The erection of the Volga hydro-power cascade with total power capacity more than 7 mill. kw is nearing completion . Five

In future when the flow of northern rivers is directed into the Volga basin the aggregate hydro-project capacity of the Volga cascade will make about 10 mill. kw.

hydro-power plants out of nine have been put into iperation already - Ivankovo, Uglich, Scherbakov, Gorky hydro-power projects with the capacity of 400,000 kw and the largest in the world Kuibishev hydro-power plant of 2.1 mill. kw. capacity, the last 20th aggregate of which is lounched on the 15th October this year.

Scherbakov hydro-power plant has the largest reservoir in Europe with the capacity of 24.5 km³, controlling the upper reaches of the Volga run off.

Two other largest by iro-power plants - Stalingrad power plant of 2.3 mill. kw capacity and Saratov by iro-power plant of 1.0 mill. kw capacity is under construction, Stalingrad power plant being put into action in 1958.

As soon as the prection of Cheboksar and Astrakhan hydropower stations is completed, the Volga reconstruction will be over.

Chirchik cascade in Uzbek SSR, Alma-Ata in Kazakh SSR and Sevan-Razdan on the Razdan River in Armenia are nearing completation as well, using old-aged resources of the mountain lake of Sevan (Gokcha).

The construction of the Dnieper cascade with aggregate capacity more than 2 mill. kv and Kama cascade with aggregate capacity of more than 3 mill. kw is launched.

Out of 6 hydro-power plants on the Bnieper envisaged in the program of lower and middle reaches of the river utilization two power-plants have been built - the Kakhovka power station with capacity \$12,000 kw and the Dnieper hydro-power station with the capacity of 650,000 kw. (This is one of the first

hydro-plants in the Soviet Union put into operation in 1932 which was the biggest in Europe before Kuibishev power plant lounching). Apart from this two more hydro-power plants - Dnieprodzerjinsk with 250,000 kw capacity and the Kremenchug hydro-power station with the capacity of 450,000 kw are being built, the latter possessing a vast reservoir with the capacity of 6.8 km³. Kiev and Kanev hydro-power plants are being designed. In the upper reaches of the Dnieper the cascade of 8 hydro-power stations is designed.

On the Kema River out of four planned hydro-power plants the Kamskaya hydro-power station near the City of Perm with the capacity of 500,000 km is put into action, and the second Votkinsk hydro-power station 1.0 mill. km is under construction and the construction of the third Nizhne-Kamskaya hydro-power station with the capacity of 1.4 mill. km will be started in the nearest future.

In Georgia the construction of hydro-power cascade is in full swing on the Khrami and Rioni Rivers. While constructing high-head Khrami power station I high mountain reservoir was formed making it possible to control seasonal hydro-power stations of the Georgian power grid.

Nowadays the cascade construction of the largest power stations on the Siberia great rivers: on the Angara, Irtish. Yenisei and Ob Rivers began. The erection of 6 hydro-stations with 10 mill. kw aggregate capacity is provided for on the Angara River, the upper Irkutsk hydro-power station with 660,000 km capacity with the Baikal lake reservoir is put already into operation.

The construction of the largest in the world Bratsk hydropower station of 3.6 mill. kw capacity with 130 m high dam is in full swing.

On the Intish River out of 15 hydro-stations of the cascade with the aggregate capacity of 2.7 mill. kw Ust-Kamenogorsk hydro-nower station has whready been erected, and the upper cascade stage of the Bakhtarmia hydro-power station with the Capacity of 435,000 kw with 90 m high dam and with a reservoir of long term control.

The cascade of 7 hydro-power stations on the Yenieei River will be of 20 mill. kw capacity.

At present the construction of one Kramnoyarak hydro-power station of the cuscade with the capacity of 4.0 mill. Fw with 118 m dam has begun.

The following Table illustrates the list of some crocades of hydro-power stations of the USSR and the rate of their appropriation.

Nos. Mares of cascades		Mames of River cascades		Number of hydro-power stations		
			· • • • • • • • • • • • • • • • • • • •			Under con- struction
1	Жеча	Neva	RSFSR			
			Murmansk Region	3	3	•
2	Svir	Svir	RSFSR Leningrad	2	2	•
3	Volga	Volga	RSFSR	9	5	2
4	Kama	Kama	rsfsr	4	1	1
5	Dnieper upper and lower reaches	Dnieper	Ukraine SSR	6	2	2
6	Chirchik	Chirchik	Uzbek SSR	19	15	1
7	Khrami	Khram1	Georgian SER	5	1	1
8	Sevan-Razdan	Razdan	Armenian SSR	8	4	2
9	Angara	Angara	RSFSR Siberia	6	1	1
0	Irtish	Irtish	Siberia and Kazakh SSR	13	1	1
1	Yenisei	Yenisei	RSFSR Siberia	7	•	1

On one hand the construction of hydro-power plant cascades with large reservoirs providing long term seasonal and diurnal control makes it possible to utilize efficiently hydro-power potential of the river and on the other hand to make navigable conditions better and to settle the question of irrigation and water supply expediently. The problems of development and state of water transport and irrigation in the USSR are given in special detailed reports by Academician A.N.Askochensky and P.A-Tumilo-Denisovich - an engineer.

The Soviet Union Appropriated Hydro-Power Station Construction in Regions of Different Nature Conditions

In accordance with state plans of electrification the hydropower station constructions are carried out practically in all
the regions of our country, as in a number of regions for example
Kolsky Peninsula, Middle Asia, Georgia, Armenia, hydro-power
resources are the main resources and practically the only
economical source of energy and in other regions the hydro-power
plants in energy systems make it possible to increase the
efficiency of power supply.

Nature conditions of various regions of the USSR - climatic, geological, topographical, hydrological are different.

In the regions of extreme North-European part of the USSR on the Kolsky Peninsula in Karelo-Finn ASSR the climatic conditions are as severe as in Zapolyare hard ice-regime, durable rock or moraine with big stones, rivers with rapids have the discharges of average value.

Derivation istallations of medium head, not high dams with gates, open canals and open hydro-power station premises. There are some underground stations as well with led out tunnels in hard rock (Neva hydro-power station III in action, and Kumskaya hydro-station under construction). In the South in the mountain conditions of the Caucasus and the Trans-Caucasus, in Georgia and Armenia, deviation medium and high head installations are in use, both with open and tunnel (head or headless) derivation and with penstocks.

A number of hydro-stations is being built and has been built

such as Sevan, Arzni, Ladzanur, Khrami II, Dekhovskaya hydropower stations. Mountain rivers of the Trans-Caucasus are characterized by sharp variations of their flow (the Rioni River, for example, from 20 m³ sec.; minimum up to extreme maximum of 2,300 m³/sec.) by great quantity of river bed alluvium and alluvium in suspension. These conditions define special types of dams and water intake installations with water clearing constructions.

Geological conditions of the Trans-Caucasus hydro-plant construction are extremely various and often complicated.

On a number of rivers water intake dams are on pebble alluvial foundations that required considerable deepening of upper and lower teeth with the help of pneumatic caissons (Chitakevi hydro-plant on the river Kura), open caissons (Paldadam on the Gori River in Georgia) and other construction projects.

The Khrami hydro-plant rock-filled dam with a metallic covering to the upstream face is built on very cracked basalt with friable volcano ash. In order to prevent filtration much cementation work has been done.

Foreign experts dujed the possibility of dam and reservoir construction under such conditions. Nevertheless the dam and the reservoir constructed in 1946 have been in successful operation for 10 years.

Derivation installations and hydro-power projects of the Trans-Caucasus hydro-stations often encounter with complicated geological conditions which are characterized by tectonical disturbance of rock (Khrami, Sukhumi and Gyumush hydro-plants and others).

Thibuli and Shaori hydro-stations in Georgia are constructed in the karst limestones where special measures were taken against filtration from the reservoirs.

The construction in Middle Asia is characterized by derivation medium hydro-stations with open derivation (excluding some Alma-Ata cascade hydro-stations).

In this region the construction of projects in losss and pebble soils on rivers bringing a considerable quantity of alluvium is typical.

Sometimes one must eliminate the mud floods.

In connection with the construction of derivation and underground hydro-power stations in the USSR tunnel construction is considerably developed. There are tunnels of 112 km total length in 23 hydro-stations and 5 irrigation systems, Neva hydro-station I led out tunnel with a large cross-section of dimensions 8.0 x 12.0 m. One of the largest and longest tunnel (7,400 m) with a head of 6.5 atm in the Khrami hydrostation I with a diameter 3.20 m are among them. Tunnels of 60 km long are under construction now at 8 hydro-stations.

In Uzbekistan at the Farkad hydro-power station a metallic penstock of 6.5 m diameter is built, for the Daryal hydro-power plant in Caucasus on the Terek River a penstock with a head higher than 750 m is designed. Penstocks with a head of 500 and 600 m have been constructed at the Khrami I hydro-power station in Georgia and at the Alma-Ata hydro-power station in Kazakh SSR.

At a number of mountain hydro-power plants, new types of water intake installations are used in dam plans (the Krasneya

Polyana hydro-power station and the Samgory hydro-power stations. The Soviet Union has little experience in constructing high arch dams. However, in Georgia the second arc dam of 70 m high at the Ladzangurik hydro-power plant is under construction now in the USSR, this economical type of a dam will be widely used at a number of new designed hydro-power stations in Georgia the Namakwan hydro-power plant on the Rioni River of 165 m high, the Inguri power plant on the Inguri River of 210 m high, the Alazan hydro-power plant on the Alasany River of 200 m high, the Sory hydro-power plant on the Rioni River of 170 m high and others. In the Soviet Union hydro-power stations of the biggest size have been built in the plain regions of middle European part of our country on the Dnieper, Volga, Kama, Svir and Don Rivers. These rivers, the Volga in particular, are characterized by wide low banks, small slopes and large irregular water discharge. The flood discharge on the Volga near the city of Stalingrad rises up to 50,000 m3/sec., that on the Dnieper at Kakhovka 25,000 m3/sec. under hard ice conditions.

The beds and banks of these rivers consist of fine grain alluvial deposits (on the Volga fine sand chiefly). Underlayer book is often also soft.

In the foundation of the Svir hydro-power installation there is plastic Devon clay! Fine sand and deteriorated silt are in the foundation of the Kakhovka hydro-plant on the Dnieper. Only the Dnieper hydro-plant installations rest altogether on durable granite.

It is of interest to note that some of foreign experts

denied the possibility of the Svir and Volga hydro-power plants

constriction under such geological conditions.

Coviet hydro-engineering worked out special types of constructions and the methods of their calculation for these conditions as well as the methods of work execution.

Technical opportunity and economical expedience of largest hydro-project constructions with strong heads on erosible foundations, fine sand, silt and peat included was shown at the Evir, Volga and other hydro-power plants.

Wide low banks of rivers require a large front for the head structures. This involves a great deal of construction work.

On the other hand, large high water flows require a consider able front for the concrete spillway structures. To lower the construction costs for such hydro-electric stations and to reduce the amount of concrete work involved, Soviet engineers have worked out several measures that were confirmed by design project and research on models in hydraulic laboratories.

The first measure calls for the design of spillway structueres and the creation of tail water flow conditions that would increase the flow through one metre of the length of concrete dams to a maximum, and as a result shorten their length.

by the fact that the maximum specific flow for the first hydrostations in the USSR was taken equal to 30-40 m³/sec., while at the present time it has been proved in practice that a flow rate of about 80-100 m³/sec. per metre in length is possible.

The second measure deals with the development of methods for calculating the transformation of high waters making use of the storage capacity in the reservoirs.

The third measure calls for new designs of power houses combined with stillway arrangements; this enables the length of spillway dams to be considerably shortened (e.g. the Kuibishev, Stalingrad, Kakhovke and Sovositirsk stations), or to entirely do away with them (the Irkutsk station on the Angara).

In some hydro-stations a part of the high water overflow is discharged through the navigation installations (the Pavlovakaya station on the Ufa River).

These measures are typical for the most recent hydre-stations in the USSR on plain rivers. That considerably reduce the amount of concrete work involved as compared with the usual projects employed earlier.

The remaining length of the head front consists of earth dams.

Research, and actual construction of these dams lawer on, proved that they could be built of practically any local material including fine sands. The hydraulic earth-moving method (method of hydro-mechanization) extensively employed in erecting these structures is characterized by a high productivity, low cost and quite satisfactory quality in laying on the material.

There are several spillway hydro-stations in existence (not containing a separate power house) with the units installed in the body of the spillway Jamz (the Kama station, the Favlovskaya station on the Ufa River, the Kairakum station on the Syr-Darya in Kiddle Asia).

The "terrace arrangement" is typical of hydro-stations on level rivers in the Soviet Union, in which all of the concrete structures (the spillwey dar, the power house, the navigation structures) are situated on the ter ace behind low cofferdams guarding the foundation against high flood waters only.

The river runs along its natural bed without constriction or with very little constriction during almost the entire construction periods This is quite favourable for navigation.

Therefore, the concrete work is done almost entirely in the dry with only the subsoil-water pumped off.

After a certain amount of concrete work has been done on the structures as well as earth work on the head race and tail race and construction work on the navigation locks and canals, the foundation is flooded, cofferdams are removed, and the river is directed through the concrete structures. Navigation is directed through the locks. The main bed is closed by a barrier of rock fill or concrete blocks thrown into the flowing stream.

This operation is usually conducted from pontoon bridges by means of dump trucks with all of the material thrown in along the entire front very quickly. The closure of the river in this way takes several hours only.

Terrace arrangements of hydro-installations, requiring a somewhat greater amount of earth work as compared with bed arrangements (in which the concrete structures are situated in the bed), are more econimical in serveral cases because the conditions under which the work is conducted are more favourable. Consequently, terrace arrangements are employed in the Soviet Union.

In erecting the hydro-installations on the folga and Unioper very large navigation locks were constructed. A lock with shafts

was constructed at the Ust-Kaminogorsk station having the largest head in the world, over 40 metres.

The current program for hydraulic development in the USSR calls for a marked increase in construction of hydro-stations in the eastern parts of the country, such as Siberia, in particular, where over 930 billion kwh of hydro-power resources are concentrated, that is, over half of the total hydro-potentia of the entire Soviet Union.

The cascades and individual stations on the Siberian rivers have already been described above. It should be noted that these rivers have enormous flows, for example, the high water flow of the Angara near the Bratsk station may reach 13,500 m³/sec., while that of the Yenisei near Krasnoyarsa 24,000 m³/sec and near Yeniseish 64,500 m³/sec.

The ice conditions on the river are quite severe due to the strong frosts in these parts of Siberia, which may fall to -50° C.

The geological conditions of the Siberian rivers are quite favourable for erecting high dams on them.

Until recently high dams were not built in the Soviet Union. The highest concrete dams are at the Dnieper station (58 m) and at the Ust-Kamenogorsk station on the Irtish River (60 m), while the highest earth dam is the Mingecraur dam on the Kura River in Amerbaijan (81 metrem) filled with a sand-gravel material by hydraulic earth-moving method.

At present the Muchterna dam on the Irtish (90 metres high) is under construction and designed for 1,000,000 m³ of concrete, and construction is getting underway on the dam at the Bratsk hydro-station (130 metres high) designed for 7,200,000 m³ of

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concrete. Preparations are being made for erecting the dam at the Krasnoyarsk stations (118 metres high) designed for 5.600.000 m³ of concrete.

All three dams are of the massive-gravitational type with temperature spacing joints.

Several other high damp are to be constructed in the near future in Siberia.

The economical index of hydro-stations in the Soviet Union is given by the following basic work figures per 1 kw of installed canacity (these figures include work done on migation structures and also auxiliary construction).

¥o•	Station	Capacit Ku	y Type of station	Con- crete work m3/kw	and rock
1	Novosibirsk on the Oh	400	at dam on weak rock	1.8	85.0
2	Irkutsk on the Angura	660	địtto	1.6	35.1
3	Rama on the Kuma	5 00		2.0	43.3
4	Bratsk on the Angara	3 60 0	at dam on hard rock	2.0	5.8
5	Krashoyarsk on the		•		
	Yeniaei	4000	ditto	1.5	2.4
6	Kuibishev on the Volga	2100	et dam on sand and		
			cla y	3.6	75.0
7	Gorki on the Volga	400	ditto	3.4	125.0
8	Gymmush on the Razdan		derivation, high hoswith combined derivation	~•/	23.6
9	Khram I on the Khrami		derivation, high heawith tunnel derivation	2•2	22.7

Pre-fabricated reinforced concrete is being used of late in the construction of hydraulic structures in the Soviet Union.

Slab type structures are being widely used that permit the concrete work to be done without forms. Of recently reinforced panel-support construction has been employed for long flooring spans without forms or even scaffolding. At the Kuibishev station 10 ton prestressed-reinforced beams of this type are used as spans at the entrances to the acroll cases of the turbines with the concrete layed on top. The head walls ans span structures for the bridge of the trash rack structure are constructed in a similar manner.

All the spans over the draft tubes and spillway opening at the Stalingrad station are made as above. The power house structure above the water level is designed of pre-fabricated reinforced concrete. Soviet engineers consider that the use of pre-fabricated reinforced concrete will result in quicker and more economical hydro-station construction because of the mechanization involved.

The Development of Hydro-Electric Construction Work In
the USSR is Marked by a Continuous Increase in the
Capacity of the Stations and the Individual Units

During the first few years after the October Revolution, the restoration of industry in Soviet Russia only began to get under way after its destruction in the course of the World War I the civil war and the intervention period.

There was no experience to be gathered from hydro-electric construction in pre-revolutionary Russia.

It is natural that under these conditions, the first hydro-electric installations in the Soviet Union were comparatively small in size. The first babies of Soviet hydro-station construction, the Volkhov station near Leningrad (1926) and the Zemo-Avchalskaya station on the Kura River near Tiflis (1927), had capacities of 64 MW and le MW, respectively.

In the period 1928-1941 many dosens of hydro-electric stations were constructed having capacities to 150 MW each. The Dnieper station (1932) had a capacity of 560 MW.

After World War II from 1950 to 1957 large installations such as the Kama station (500 MW), the Gorki station on the Volga (400 MW), the Mingechaur station on the Kura (567MW), the Irkutsk atation on the Angara (660 MW) and the Kuibishev station on the Volga (2100 MW) were put into operation.

At present installations such as the Saratov station (1,000 MW), the Votkinsk station on the Kama (1,000 MW), the Stalingrad station (2,300 MW), the Bratsk station (3,600 MW) and the Krasnoyarsk (4,000 MW) are under construction. Ever still larger stations on the Yenisei (6,000 MW) and on the Ob (5,000 MW) are now in the design stage.

It should not be concluded, however, that stations of smeller capacity are not being constructed in the Soviet Union. Stations of this type depending on the local conditions are also con
structed in a large number; however, considering the large
ecobomy gained from large stations, the possibility of transmitting power over distances of 1000 km (and more) at 400 and 500 kV
and also the greater productive capacity of the building industry in the Soviet Union at the present, priority is given to the

construction of the more economical large hydro-electric stations. When the latter will have been put into service, the power balance in the country will undergo a sharp change for the better

The rating of individual units is increasing alongside with larger hydro-station capacity. At present, the units installed in the stations of the Soviet Union are entirely of domestic manufacture, and in the main from the Leningrad Metal Works.

At the Volkhev station the units were of 8 MV and at the Zeno-Avchalskaya station of 3.2 MV; at the reconstructed Dnieper station safter the war the rating of the units rose to 73 MV each; at the Eulbishev station large Esplan type, turbines are installed whose water wheel has a diameter of 9.3 m; it generates 108.5 MV at the design head of 19 m and 126 MV at the maximum head of 22.5 m.

Francis type turbines have been designed for the Bratsk station that will generate 200 MW at a head of 96 m. This turbine has successfully passed model testing.

Finally, propeller type turbines are being designed for the Krasnoyarsk hydro-station; they generate 285 MW at a head of 96 m.

These large water wheels considerably reduce the power house construction and greatly simplify the operation of multi-unit stations.

Gonsolidating Hydro-Electric Stations Into Power Systems
and Developments in 'Automatisation and Telecontrol of .

Hydro-Electric Stations

The consolidation of stations into power systems is at present the main trend in the development of the power economy

in the Soviet Union.

It was called for even as far back as in the GOELRO Plan and has been put into life on a large scale.

A large number of power systems have been formed in the country consolidating steam and hydro-stations through 110,220 and, of late, 400 EV transmission lines.

The consolidation of power systems on an intra-regional basis has already been started, and at present there already exist three large intra-regional consolidations, the Centre, Urals and Southern power systems.

The law concerning the sixth five-year plan for the development of the national economy of the Soviet Union calls for the formation of a single consolidated power system in the European part of the Soviet Union by tying together the Knibishev and Stalingrad hydro-stations with the Central, Southern and Ural power systems through 400 kV transmission lines.

The Georgian, Armenian and Azerbajanian power systems are also to be consolidated, and work is to be started for creating a single power system for Central Siberia from Movosibirsk to Irkutsk.

Consolidated power systems, in which hydre and steam station operate in parallel, will greatly improve the economic aspect of power station operation. Hydro-stations that may start generating their power within a few seconds are most effectively used for taking on peaks in the load curve, thereby relieving the steam stations to a maximum from this function.

Bith hydro-plant taking on the peaks in the load curve, thermal plant may operate uniformly in the course of the day at

the base of the lead curve, which is tantamount to optimal operation for these stations.

The importance of these advantages is evidenced more so when consolidating power systems, and especially, when there are large hydro-stations in some of these systems, and none in the others.

The consolidation of power systems is very advantageous when hydro-stations work on rivers with different hydrological conditions.

In the development of power systems and the formation of a single consolidated power system, automatic control of an individual hydre-station as well as telecontrol processes for the entire system as a whole begin to play an important role.

All regional hydro-electric stations in operation in the Soviet Union were already equipped with automatic control devices in 1952; at the present all new hydro-stations are put into operation with automatic control.

More than 60% of all hydro-stations have telecontrol from wentral posts; all hydro-power stations of Tchirtchik Gascade for example are controlled from a single dispatcher's post; the Khram I station 100 km from Tiflis is controlled from the central dispatcher's post of the Georgian power system.

Automatic control and telemechanics enables the number of station attendants to be considerably reduced (by 2.5 times as compared with 1950); it also sharply reduces a quantity of accidents by 5 \$0 6 \$imes, and increases the efficiency and speed of control, thereby increasing the utilisation of the water power to above 5%.

Mechanization in Hydro-Power Plants Construction

The extent of hydro-power stations construction in the Soviet Union may be gathered from the following figures:

Period	Earth work, million m ³	Concrete work, million m ³	Assembling of metal construction thousand tor
1946-1950 - 4th five-year plan	94	2.7	70
1951-1955 - 5th five-year plan	774	16	888
1956-1960 - 6th five-year plan	880 x)	38 x)	1930 x)

The main tendency in construction practice in the Soviet Union is maximum mechanization of the work.

The following figures may give some insight into the extent that mechanization is employed in the construction of hydro-stations:

Work	Mechanization, #					
	1940	1951	1956			
Earth and rock works	47.0	90.4	96.7			
Concrete works	23.9	90.3	97-2			
Assembling of metal						
construction	40.0	97.0	96.2			

At present only the cleaning by the earth and rock excavation and various kinds of odd jobs, where big means of mechani-

x) These data are approximate and will be more precise in final plans.

zation is difficult to introduce, are done manually.

Earth and Rock Works

In the construction of hydro-electric stations earth works are conducted with excavating equipment by dry method as well as by the hydro-mechanization method.

In the 5th five-year plan 35% of 270 million cubic metres of the total (774 million cubic metres) earth and rock works was carried out by Aydro-mechanization.

Caterpillar power shovels with 1, 2, 3 and 6 m³ buckets of Soviet manufacture (in the main electric ones) are used for "dry" work.

Diesel excavators with $0.15~\text{m}^3$ buckets on pneumatic wheels and caterpillar excavators with $0.5~\text{m}^3$ buckets are used for odd jobs.

The excavators work almost enirely with 3.5, 5, 10 or 25 ton dump trucks depending on the bucket capacity.

For the large excavations without transport - "walking draglines" (also of Soviet manufacture) having 4 m³ buckets and 40 m booms, and also 14 m³ buckets and 65 m booms are used; they have a productivity of up to 1000 m³/hour.

Bulldozers on 80 h.p. tractors and 6 cubic scrapers are widely used; 140 and 250 h.p. bulldozers and also 10 and 15 cubic scrapers are starting to be used.

Rock work is done with hammer and rotary type drills, hard alloys, electric-scorching and slightly delayed explosions with multi-second retardation.

The main equipment used for earth works by hydraulic earth-

moving meghods (hydro-mechanization) consists of hydro-monitors and floating earth suction dredges.

From 1948 to 1952 the following line of suction dredges were manufactures, types 300-40; 500-60 and 1000-80 (the first number indicates the theoretical productivity for earth in m³/hcgr, while the second figure the head in metres).

For transmitting the water-earth mixture through a pipe line over a long distance, intermediate pumping stations are used.

At present the suction dredge units are automatically controlled, and measuring apparatus with radioactive isotopes are employed to indicate the consistency of the water-earth mixture.

Eydro-mechanization was introduced in the Soviet Union on a large scale not only for excavating foundations and canals, but also for hydraulic filling of earth structures and dams.

The scale of earth works for hydro-station construction in the USSR may be appraised on the basis of the data given below for several stations built on plain rivers.

No.	Station	River	Excavation work, million m ³	Embankment work, million m
1	Kuibishev	Volga	76	80
2	Gorki	Volga	21	29
3	Kremenchug	Dnieper	22	36
4	Kakhovka	Dnieper	17	13
5	Movosibirsk	Ob	14	20

The greater part of the excava lon work was done in fine sands with a high level of the subsoil water.

It was possible to do this large amount of work under the above conditions within the short time limits set only by using hydro-mechanization, since the latter does not require that the foundation excavation be drained dry previously.

The hydro-mechanization method is practically the only solution to the problem of erecting earth dams on river beds after harnessing the beds with rockfill (it was used on the Volga, Dnieper, Kama, Ob, Angara), since it is necessary to lay on a large amount of earth in the body of the dam before the spring floods.

Earlier the hydraulic fill method was employed in building these dams requiring the erection of a high scaffold bridge for the pipes; here, the material is washed down along the entire length of the dam.

Recently, a more effective and economical method of filling has been developed in the Soviet Union not requiring a bridge and ensuring a thin-layer fill. It makes use of special connections that may be quickly disassembled which cermit its use for filling fine-sand dams.

Hydro-mechanization allows dam construction to be carried out at a high tempo, since it enables an enormous amount of work to be carried out in a short period of time.

For example, at the Kuibishev station, the first unit was put into service five years after work had begun, and 70 million .m³ out of the total 156 million m³ was done by the hydro-mechanic mation method; the tempo of the ground works are given below.

	Dali oi measurement	Amuunt	5	
	acar al givent	Total	Dry method	vdro-mecha- nization method
In a year	million m ³	40.0	21.0	28.0
In a month	million m ³	7.5	2.1	5•4
In a day	the issued m ³	420	120	300

The hydro-mechanization method could not be employed earlier in the winter time.

2015 deficiency was eliminated during the construction of the Kuibishev station in the winter of 1955-56 at temperatures to =30°C, when a concentrated rill of large intensity was organized and several special measures were taken against freezeige. From October, 1955 to April, 1956 more than 5 million m³ of sund was filled into the dam body. The winter filling experiment was successfully repeated at the Stalingrad and Novosibirak stations in 1956.

Concrete Forks

The growth of concrete works for the construction of hydrostations during the five-year periods was given at the beginning of this section.

Large hydro-stations require an enormous amount of concrete works. To illustrate this statement, data for some of the most recent installations in the Soviet Union are given below:

No.	Station	Capacity	Amount of concrete work, thousand m
1	Bratsk	3600	7200
2	Kuibishev	2100	7600
3	Irkutsk	66 0	1.000
4	Movosibirsk	400	720
5	Gyumah	220	420

Concrete work at hydre-station projects usually lasts from 2 to 3 years; moreover, in the busiest one year period, up to half of the concrete is poured. Hydre-station sites in the Soviet Union are supplied with special highly productive equipment to maintain the rapid pace of the work.

Ye.	Station	Amount of	Maximum amount placed per				
	·		year thousand m ⁵	Heath thousand m	day_3		
1	Kuibishev	7600	3150	390	19050		
2	Kakhevka	1422	668	80	4500		
3	Dnieper	1180	528	110	5270		
4	Verchme-Svirsk	600	•	38.5	1910		

This high tempe, at which the concrete is poured, is also ensured by the widespread introduction of industrial methods such as: the use of carcass reinforcements instead of individual steel bars, slab-structures instead of forms, reinforced form blocks, reinforced panel constructions, prefabricated reinforced concrete elements, bath welding, etc.

The rainforcements are made at special plants, where there are contact and multi-point wolding machines, large bending stands for rods to 100 mm dia., and machines for cutting the rods.

The basic type of concrete-mixing plant in use is an automatic vertical type plant with each section having four 2400 or 100 litre concrete mixers situated in pigeon hole order exalong a line with weight type dosing tanks.

The cement warehouses at the plants consist of a bank of metal store towers each having a capacity of 1000 m³ and with a pneumatic delivery line for the cement. There were three such plants at the Kuibishev hydro-station project; two of them consisted of four sections having 2400 litre concrete mixers and with 20 cement storage towers.

Plants are being constructed for the Bratsk and Krasnoyarsk stations having 4500 litre concrete mixers.

The concrete mixture is transported from the plants to the site in various ways:

- a) on dump trucks unloading directly into the blocks, or with intermediate unloading into special buckets hung from a caterpillar crane;
- b) in 1.5, 3.0 or 6.0 m³ buckets on trucks or railway flat cars? they are unloaded onto the block by portal-boom cranes, tower-cranes or double-cantilever cranes having a hoisting capacity of 10, 20 or 40 tons, or in buckets lifted by cable cranes:

- c) on belt conveyors:
- d) by concrete pumps having a delivery to 40 m3/hours
- e) in railway bunker cars delivered onto the concrete block through vibrating tubes.

The use of scaffold bridges for transporting the concrete is justified despite the metal expenditure and time for assembly, since it allows the high position for cranes to be made and provides a wide front of delivery of the forms, reinforcements and concrete.

These scaffold bridges allow also to pass the waterflow through the unfinished superstructure of the concrete construction.

The spans of these scaffold bridges are used afterwards for the permanent bridges across the spillway dams.

The concrete is placed onto the blocks either by meens of individual vibrators or by vibrator groups hung from cranes.

In order to economize cement and improve the quality of the concrete, plastifying materials are added.

It is quite important to be able to carry out concrete work in the winter time in the central and northern sections of the Soviet Union.

Soviet engineers have worked out mothods permitting concrete to be poured at practically any frost (the thermos method, the method of peripheral electric heating, the steam heating method, etc.).

Large scale experiments were carried out during the construction of the Svirsk, Gorki, Narva and Kuibishev Hydro-stations on introducing continuously operating concrete plants. Prefabricated reinforced concrete plants and plygons are constructed on site to manufacture the reinforced concrete constructions.

In constructing locks at several hydro-stations (the Kakhovka, Stalingrad and Novosibirsk stations) pre-stressed reinforcement of monolytic constructions for the bottoms of the locks is done without jacks by the gravitational method, where the reinforcements are stressed and the concrete is pressed due the deformations (settling) of the lock walls, which take place in accordance with a pre-established work schedule for concrete and earthfall works.

Large mechanized quarries with rock crushing and screening plants are created to obtain the required amount of and quality of aggregate for the concrete.

At several mountainous sites, where there is no natural sand available, rock is crushed to obtain sand.

Methods of Driving in Metal-Sheet Piling and Piles

In constructing hydro-stations on soft earth, metal pilesheet are widely used in the Soviet Union to fence off foundation excavations and to create anti-filtration sheets in the foundation of structures.

At present a new method of vibration pile setting is employed in sandy soil instead of the ordinary methods using Diesels or pneumatic hammers.

A special electrical vibrator making 1600 to 2500 escillations per minute is set down on top of the soil, and as a result, the pile under its own weight sets itself into the earth. This

method was employed at the Kakhovka, Gorki, Kama, Stalingrad and other stations where pile setting to a depth of 18-20 metres was required. The average work rate is about 4 to 6 metres per minute. The productivity per shift is about 20 to 30 piles, that is, twice as great as with pneumatic hammers. The cost is twice as less. In all, 70,000 piles of one type and 35,000 of another were set by this method.

A vibration-hammer technique is being developed now for clay soils.

Vater Brain

At the greater majority of hydro-stations on soft soil in the Soviet Union the subsoil water level is lowered by means of a system of depth pumps situated in wells around the foundation excavation.

A single-row single-circle arrangement of these wells enables the ground water level to be dropped by 20 metres.

Depth draining is superior to surface draining because the water does not flow in the foundation excavation, and therefore its bottom and slopes do not become loose as a result of hydro-dynamical forces from the water.

Consolidation Processes of Soils

Much work is done in the Soviet Union on cementation and bituminization rock in connection with the construction of hydrocelectric stations and tunnels in rock with cracks.

Of late, work has been done to consolidate sand-pebble deposits and to create anti-filtration sheets in them.

The Closure of Large Rivers

The means of closure of large rivers in the USSR by dumping rock and concrete blocks into the flowing stream was already mentioned above.

Besides throwing on a rockfall barrier from pantoon bridges, another means was employed successfully at several sites (at Movosibirsk and Buchtarminsk) where there was hard rock under the alluvium layer. It is called the "pioneer" method; here, the dumping is done from the banks of the river towards the centre, without pontoon bridges.

After the barrier is formed and the river is diverted throug the concrete structures, the earth dam in front of the barrier is filled.

The rock is thrown in by 5 and 10 ton dump trucks.

The Table given below shows how several rivers in the Soviet Union were closed:

Station	River	flow at time of closure m3/sec.	Specific water flow, m3/sec. per m in length	Drop, metres	Material for closure	Time for clo- sure
Gorki	Volga	1200	4.7	0.88	broken rock, rock and concrete cubes to 3 tons	12
Kama	Kama	1400	9•3	1.40	" u	144
Irkutsk	Angara	1,900	10.4	1.54	11	15
Kakhovka	Dnieper	2000	8.2	0.74	n	48
Kuibishev	Volga	3800	11.5	1.93	Broken rock and 10 ton concrete pyramids	

The theoretical basis of this method was worked out in the Soviet Union as early as in 1932. It was continuously checked in the laboratory on models and in the field.

At present the problem of closure rivers by dumping rock or concrete blocks into the flowing stream may be considered to be technically solved for all cases that may be encountered in practice in the Soviet Union. All that is required is a technical and economical basis for selecting one or another means.

Assembling Works in the Construction of Hydre-Electric Stations

The sequential installation of turbine-generator units, which are assembled on site from separate parts, requires a great deal of time and is not capable of putting these units into service in short order.

Soviet engineers worked out and introduced an accelerated method of assembling the units in large blocks.

This method is as follows for the construction of hydroelectric stations:

The fixed parts of Kaplan turbine and the control apparatus
for the turbine are layed.

An assembly landing is made right next to the power house or near it; this landing should be large enough for placing several units. It is equipped wither with rails on a scaffold bridge for the overhead cranes of the hydro-station to travel on (Kuibishev station), or with rails for the local wagons and a horse crane of the required hoisting capacity (Mingochaur station).

Large parts are assembled on this platform, for example, the turbine water wheel, the generator roter, etc.; they are then delivered either by car or directly on the overhead station crane to their point of installation. The assembled parts weigh up to several hundred tone. This approach enables the equipment to be creeted at the same time as construction work is being carried out at the station, and considerably accelerates the time required for putting the units into service.

The time saved in installing the units using this new method as compared with the old one, is given in the Table below.

Station	Time for assempling, days		Units put into service
	014 mothed	New nethed	(days).
Scherbakev	150	•	
Low Svir	265	•	
Heletev	•	38	•
Exibishev	•	45	after 30 days
Gorki.	•	45	•
Isohemateim			
(Austria, 1954)	150	•	after 90 days

Auxiliary Plants and Settlements Built While Constructing the Hydro-Electric Stations

The construction of large hydro-electric stations require many auxiliary plants and large settlements for the workers, office personnel and their families.

These auxiliary plants may be divided into two groups.

The first group consists of temporary plants which are dismantled after the construction has ended, such as concretemixing plants with their cement and filler warehouses, plants
for einforcements, storehouses, offices for construction
brigades, pumping stations for draining, etc.

The second group consists of premises, which remain even after the construction work has terminated, and are utilized as industrial plants in the region. They consist of repair and machine plants and shops, woodworking shops, sutomobile garages, prefabricated reinforced concrete plants, mechanised quarries, and rock-crushing and screening plants, etc.

The above listed plantes are built to last, fundamently.

The construction site is supplied with electric power from regional stations through high voltage transmission lines that are built. It is frequently the case that these lines are used for transmitting power from the hydro-station after the construction work has ended.

The amount of electric power used at large construction sites can be gathered from the fact that the sub-stations at the Kuibishev station had a capacity of 120 MW.

Small cities with modern conveniences are built for those whe are engaged in the construction of the station, since their numb

at a large project may reach dozens of thousands. A large part of the houses there are fundamental with theatres, movies and clubs, shools, stores; medical and child welfers institutions. There are up-to-date pavement, lawns and gardens, water supply, sewage and thermofication facilities in these cities.

That is the way cities like Voljsk (at the Stalingrad station), Mingechaur (at the Mingechaur station) and Novo-Kakhovka (at the Kakhovka station) look like, as do the towns at the Novosibirsk and Kremenchug stations, as well as many others.

In the future, people working at the industrial plants in the area will live there.

Design and Research Work

The prospecting and design work for large hydro-electric projects with structures for navigation is conducted by two project institutes of the Ministry of Power Stations: Gidro-energeproject and Gidroproject. They have their branches in several large cities in the Russian Federation and in other Republics of the Soviet Union.

Rural power stations are designed by the Institute Ciproseldctro of the Ministry of Agriculture.

Water way structures are designed by the Institute Gipreretchtrans of the River Transportation Ministry.

Irrigational structures are designed by the Institute Giprevodkhoz of the Ministry of Agriculture.

Research work connected with the study of structures designed and built at the hydro-projects, and also with the solution of scientific problems that arise in the course of construction is at a large project may reach dozens of thousands. A large part of the houses there are fundamental with theatres, movies and clubs, sphools, stores, medical and child welfare institutions. There are up-to-date pavement, lawns and gardens, water supply, sewage and thermofication facilities in these cities.

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conducted within the Ministry of Power Stations at the All-Union Scientific Research Institute for Water Power Engineering (VNIIQ) in Leningrad, at the Tiflis Scientific Research Institute for Structures and Water Power Engineering (TNISGEI) and at the Scientific Research Section of Gidroproject in Moscow.

Aside from this, an institute for organizing power construction, Organergostroi, has been set up within the Ministry of Power
Stations. It deals with questions of industrializing the
construction of power stations, with all round mechanization,
with the introduction of new techniques in the construction
field and with technical information.

Construction problems in the irrigation and water transportation fields are studied at scientific-research institutes within the appropriate Ministries.

Research in the field of water power potential in the Soviet Union is conducted within the "inistry of Power Stations by the institutes Gidroenergoproject and Gidroproject, and by the USSR Academy of Sciences (of which the Council for studying the productive forces of the USSR, the Water Development Research Council, and the Krzhishanovsky Power Institute are all a part), as well as by the Academies of Sciences of Republics of the Soviet Union, such as the Ukrainian, Georgian, Armenian, Kasak and Uzbek Academies.

Hydrological and meterorological conditions in the Soviet
Union are studied at the Central Administration of the HydroMeteerological Services, at the 'State Hydrological Research'
Institute and at the Central Institute for Weather Forecasting.

The development of hydro-electric construction in the USSR led to great progress in the field of knowledge of water power

engineering.

Soviet scientists have worked out methods (confirmed in practice in the field) in hydraulics which enable all basic problems to be solved with confidence, such as flow through water power structures which includes questions of non-uniform flow in open beds of arbitrary section, non-stealy flow in open beds and in headwater systems, energy destroyers and junction of overfalling sheet of water with tailwater surface, deformation of erosible stream beds and consolidation of them, etc.

Subjects such as geological engineering, soil mechanics and filtestion theory, and the flow of soil water under water power structures have been worked out in detail.

A clear cut picture of the behaviour of structure foundations enables Soviet engineers to erect the largest of structures
under the most complicated geological conditions and on soft
subsoil. In doing so, the underground contours of the head
structures, their stability factor, possible deformation and
settling, etc. may be calculated with sufficient accuracy.

A great deal of work has been done in the theory of structures. Methods have been developed for calculating water power structures on an analytical basis and also on experimental power structures on an analytical basis and also on experimental one employing models; optical, tensometric and stereometric methods are used as well as the method of electrodynamical analogy.

For constructing hydro-stations on mountain rivers with a large number of bottom and suspension silts much work has been done to study the flow of silt and the leformation of the river

beds. Methods for calculating and constructing of water intakes, settling basins and sluice structures.

In connection with the widespread use of hydromechanizations the theory for hyraulic soil delivery sha been worked out.

In the field of hydrology and water power calculation,
Soviet scientists have developed a theory for forecasting hydrological characteristics that replaces earlier used empirical methods. It enables a solution to be obtained to the most complicated problems in water power regulation when all-round use is made of the water stream in hydro-station cascades.

A great deal of work has been done by Soviet engineers on production techniques in the preparation of concrete for hydraulic structures. As a result, high-arrength, anti-seepage and anti-frost concretes may be obtained expending a minimum of cement.

Results of research work are generalised in the Soviet Union in the form of technical regulations and standards for design practice and also for various kinds of jobs. These regulations and standards are obligatory for all design and construction bureans, and remain in force for a certain period of time until new data is obtained.

Soviet scientists and engineers have written fundamental works on all topics of hydro-station construction. They enhance world scientific progress and experience in this field.

Organization of Construction Work

The construction of large hydro-electric stations is organized by the Ministry of Fower Stations.

There is a main department within this ministry that is

concerned with this construction work at hydro-electric stations.

This department (or Clavk as it is called for short in Russian) organizes an ovvice for the construction work at the station site. It is headed by a manager in charge of construction, and a cheif engineer. After this office has been created, all of the main works are conducted through it.

The function of the Glavk is to give general technical assistance, to plan the work, and also to supply the project with materials and technical service.

The construction office signs contracts with special organizations (trusts) within the Glavk that serve all projects to carry out special jobs such as to dry the foundation excavation, to consolidate the soil, to perform hydro-mechanised earth works, to install gates and hoisting mechanisms at hydraulic projects, to install power equipment (turbines and generators) and electrical equipment. After the hydro-station has been constructed, it is turned over to the regional board of the power system for operation. This board is subordinated to the National Economy Soviets (Sovnarkhoz for short in Russian) for the given economic region.

While the station is still in the construction stage, these boards appoint a body of managers at the project, which receives all incoming credits for the station; and which signs work contracts with the construction office for building the station (the Board in this case takes the part of the customer), and also with the general contractor. Afterwards, the Board receives monthly statements from the general contractor specifying the amount of work done and it pays out

(in accordance with bills) through the netrest branch of the Industrial Bank of the USSR.

After the hydro-station has been constructed, it is accepted by a government commission and turned over to the power system board for operation.

The personnel and mechanized wquipment formerly engaged at the completed project are directed to a new site by the construction Glavk.

The construction of several small hydro-electric stations is organized directly by the National Economy Soviets in the various economic regions.

Eristov

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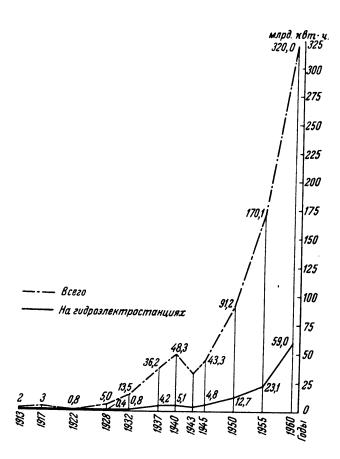


Fig.I

КАРТА РАЗМЕЩЕНИЯ ГИДРОЭЛЕКТРОСТАНЦИЯ

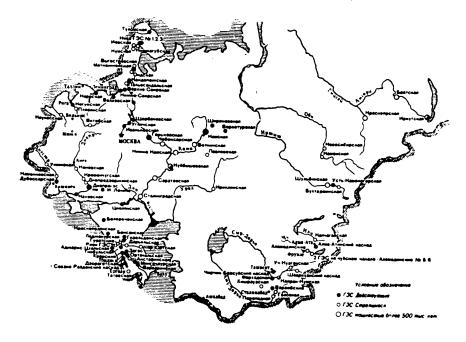


Fig.2

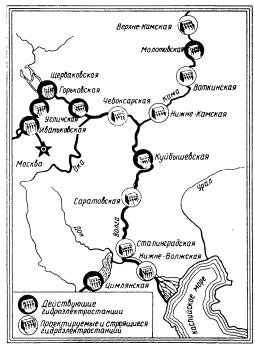






Fig.4

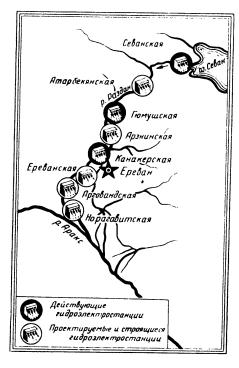


Fig.5



Fig.6

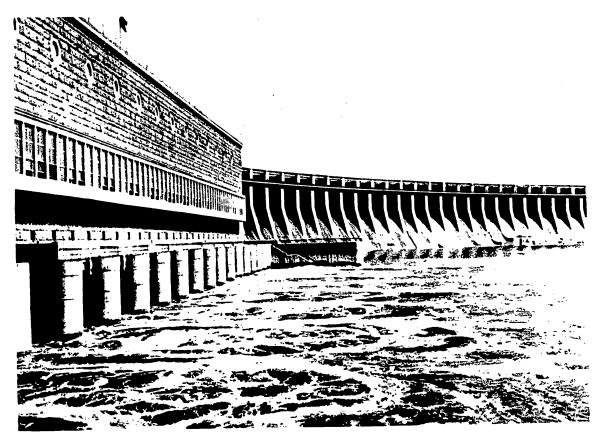
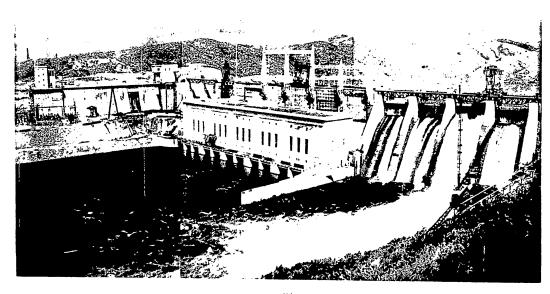


Fig.7



F13.5

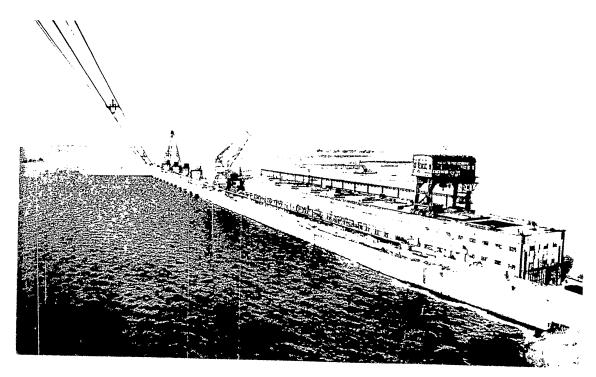


Fig.9

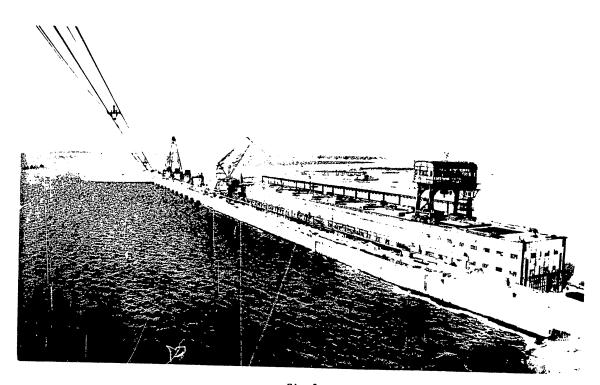


Fig.9

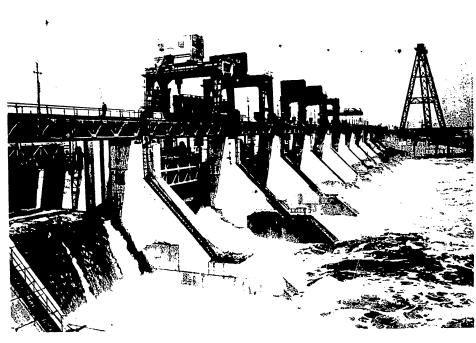


Fig. 10

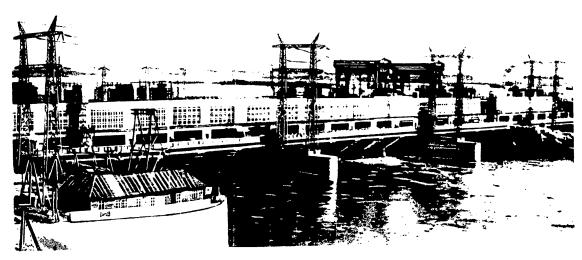


Fig.II

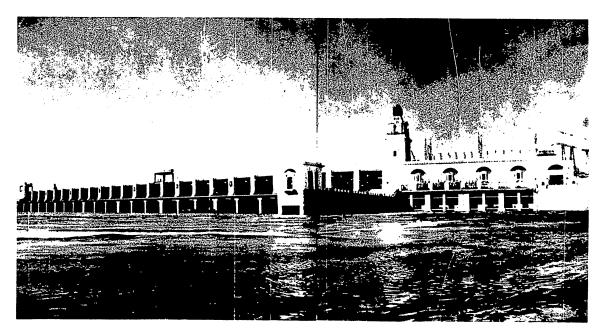


Fig.I2

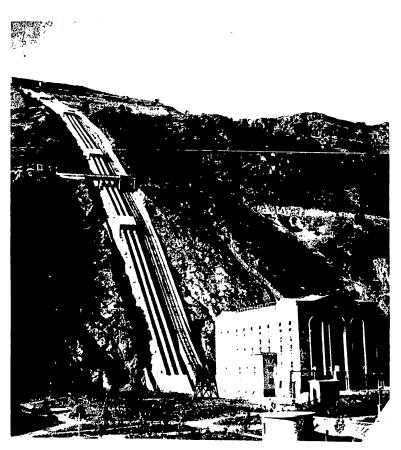


Fig.I3

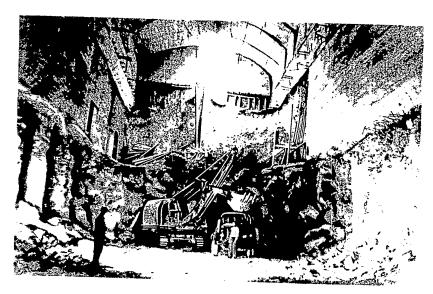


Fig.I4

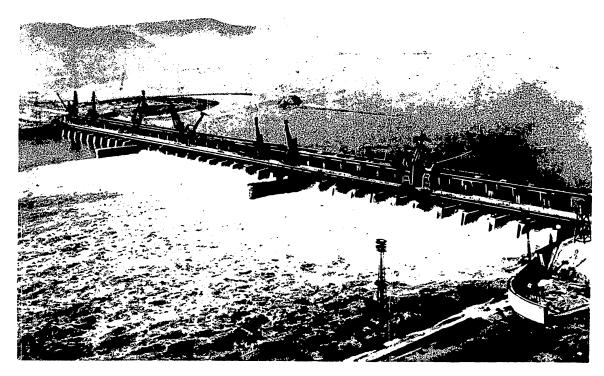


Fig.I5

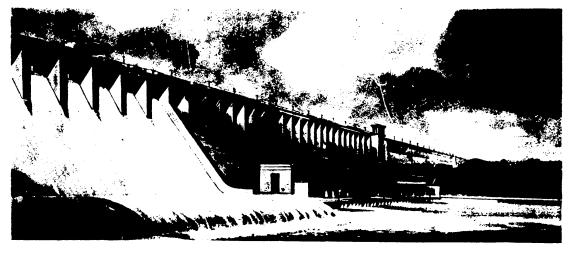


Fig.16

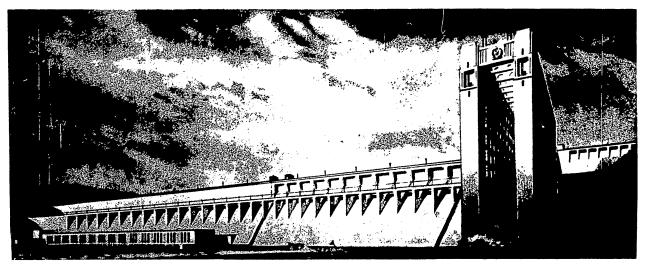


Fig.I7

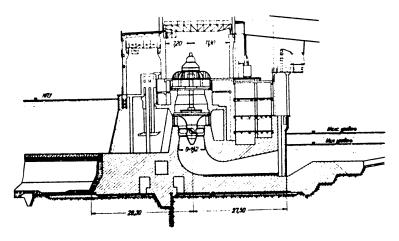


Fig.I8

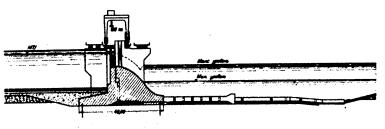


Fig. 19

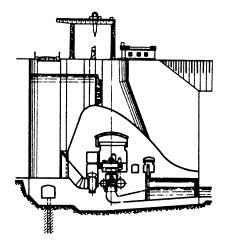


Fig.20

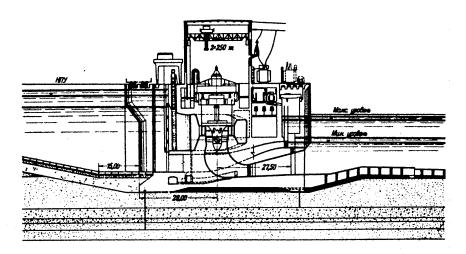


Fig.2I

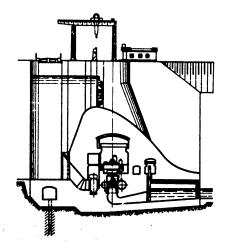
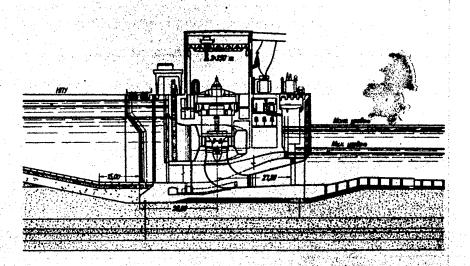
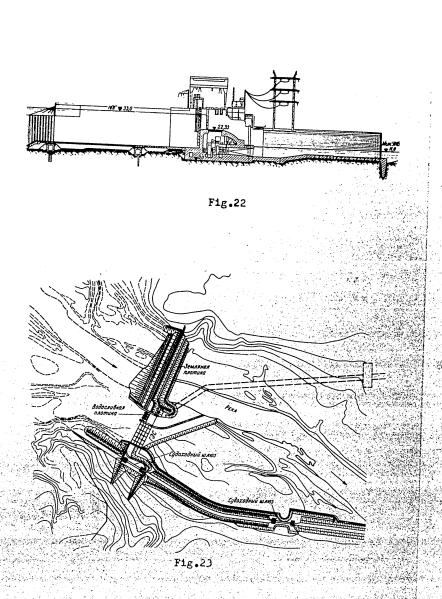


Fig.20



F1g.21



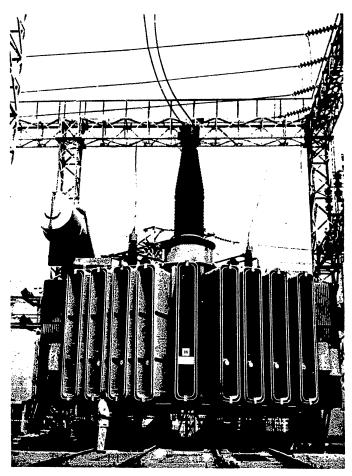
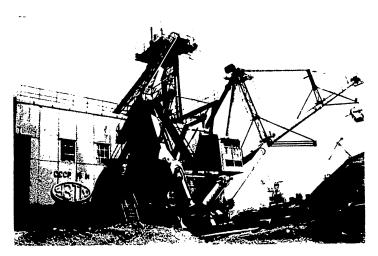


Fig.24



Fig.25



F1g.26

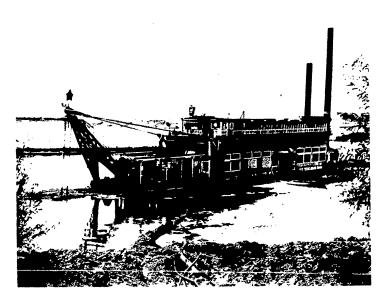


Fig.27

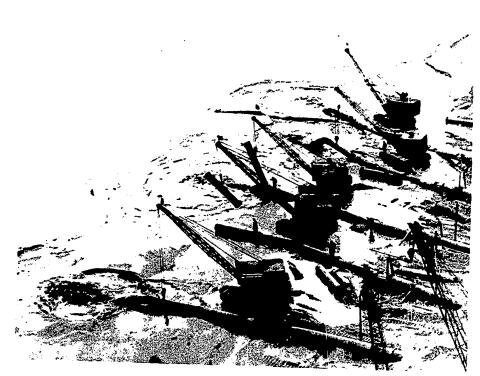
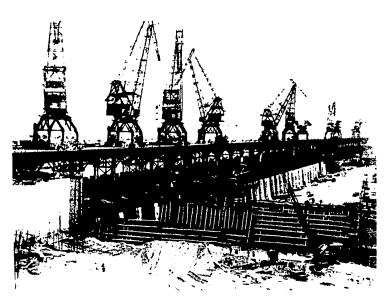
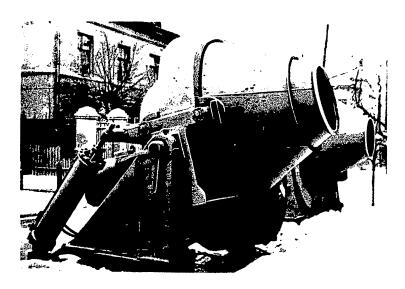


Fig.28



F1g.29



F1g.30

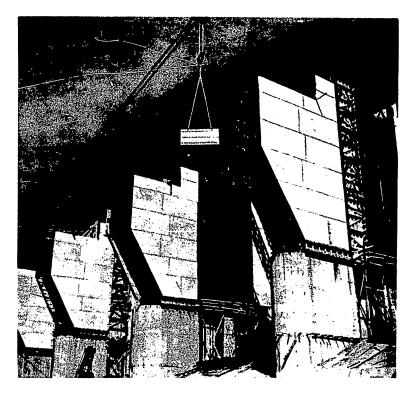


Fig.3I

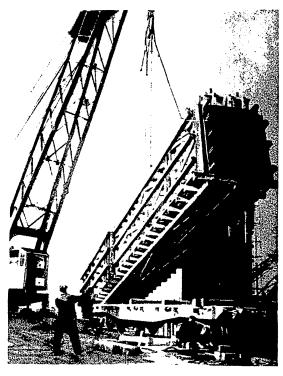
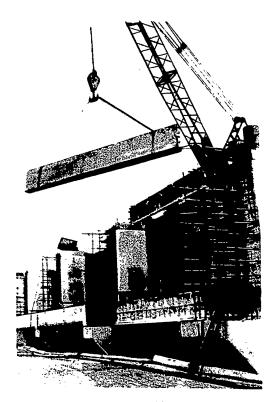
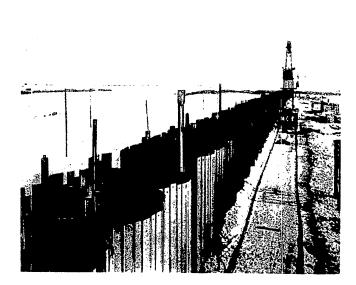


Fig.32



L1 - 13



Fir.34

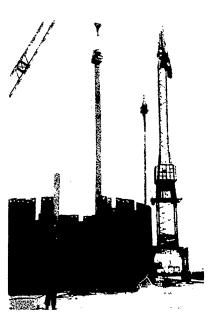


Fig.35

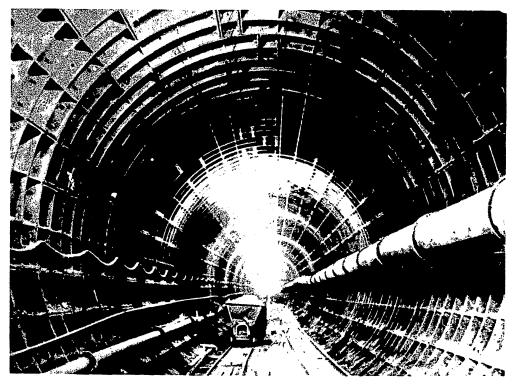


Fig.36

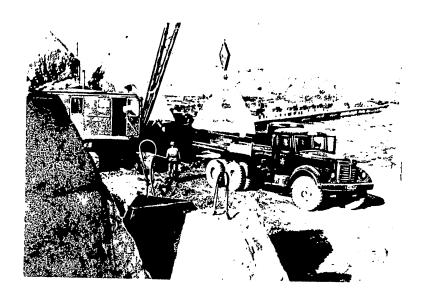


Fig.37

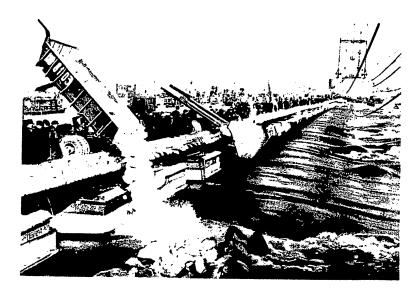


Fig.38

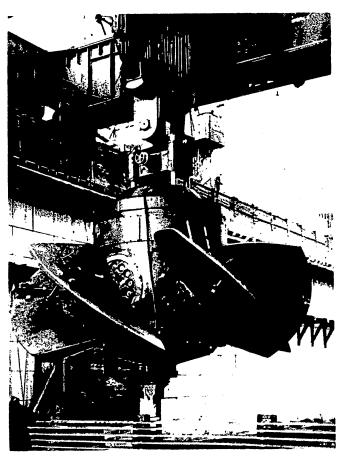
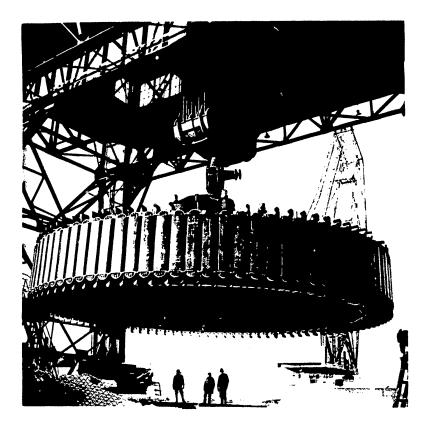
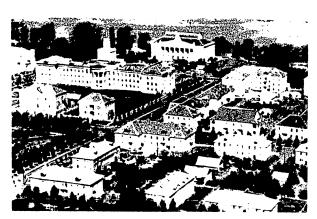


Fig.39



F1g.40



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